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Water Cherenkov detectors with fiber enhanced PMT for cosmic ray observation

We present a novel design for Water Cherenkov Detectors (WCDs) that integrates small photomultiplier tubes (PMTs) with wavelength-shifting (WLS) fiber bundles. A prototype detector was constructed and rigorously tested under various configurations, including vertical, inclined, and peripheral muon incidences, as well as self-trigger operation.

Key advancements include the introduction of WLS fibers to redirect Cherenkov photons toward the PMT, significantly improving photon collection efficiency compared to standalone small PMTs. Comparative tests demonstrated that the fiber-PMT configuration achieves a marked enhancement in light yield, validating the critical role of fibers in expanding the effective detection area. While a slight trade-off in time resolution was observed due to photon reemission processes in fibers, the detector maintained robust performance across all tested scenarios. Notably, the system exhibited reliable self-trigger capability without external devices, highlighting its adaptability for remote or modular deployments.

By integrating compact PMTs with optical fibers, this design provides a low-cost alternative to traditional large-PMT WCDs without compromising detection capabilities. Future work will focus on optimizing the structure of fiber-PMT to further improve efficiency. The results underscore the potential of fiber-enhanced small PMTs in next-generation cosmic ray observatories and large-scale astrophysical experiments. We present a novel design for Water Cherenkov Detectors (WCDs) that integrates small photomultiplier tubes (PMTs) with wavelength-shifting (WLS) fiber bundles. A prototype detector was constructed and rigorously tested under various configurations, including vertical, inclined, and peripheral muon incidences, as well as self-trigger operation.

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Collaboration(s)

Authors: FENG, Cunfeng (Shandong Universtiy); SUN, Hao (Shandong university)

Presenter: SUN, Hao (Shandong university)

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